TECHNICAL PAPER

LED Stereoscopic Movie System and "3D Vertigo Syndrome"

By Chao Li

Abstract —The development of LED display has reached the most advanced stage under the catchword of "Return me to the true visual world----HD+3D!" The research and development for deep level theory of LED 3D system has been proceeding many years and has gained very good result in different respects. One very important thing compared with stereoscopic projection movie player is that the so said "3D vertigo syndrome" effect can become very low and could be almost omitted. This is to say further theoretical research for LED 3D display is very necessary.

Key words: 3D, LED, Polarization, DCHD, 3D vertigo syndrome

INTRODUCTION

As digital technology overtook traditional film technology for movie cameras, some display development engineers put their minds to considering the consequences and opportunities that would occur when digital LED movie player systems would replace the traditional film systems in cinemas.

The world of traditional film technologies as we have known it, is over. From detailed research, we understand that the selection of LED display technology instead of digital projection is very important. In addition to many technical advantages over digital projection, we can show that the typical "3D vertigo syndrome" is not apparent in the Double Channel High Definition (DCHD) LED system. From a human health point of view this is a very important achievement.

DEVELOPMENT DESCRIPTION

A "Polarizing 3D LED Giant Display System" developed and manufactured in China, has passed technical approval. There is however a big difference between this occasion and others as the "Double Channel HD (DCHD) Polarizing 3D LED Giant Display System" is a Chinese developed and patented technology.

The world's first electronic shutter mode 3D LED video display was designed and produced here in 1997 by a Chinese company. When the promotion was made to market, it was said that for large video display however, the shutter mode technology would not be welcome, as the cost of shutter glasses is very expensive and the management of the glasses in a public place is also difficult. It was also considered that the 3D result of the shutter system was poorer than that of a polarizing system. Since then the research and development was started to address both the polarizing mode and naked-eye mode for LED 3D displays, and the latter should be for advertising application.

In 2010 the first naked-eye 3D LED video display was produced. In June 2011, the world's first Double Channel HD polarizing 3D LED video display sample had been design–proven and produced. The Chinese company then became the world's first manufacturer to produce all the three categories, "Shutter mode, Naked-eye mode and Polarizing mode", of 3D LED video displays.

Fig. 2.1 The first DCHD polarizing LED 3D movie system.

At the technical examination meeting in Zhengzhou China on 30th of March, 2012, all of the top ranking film and TV experts in China indicated that the 3D LED Giant Display System has a lot of advantages over the commonly used digital projector

systems. Its brightness is as high as 15 times greater, the contrast ratio is dozens times greater than that of a projection system, and as the picture of the LED system is very sharp with neither defocusing nor misconvergence, the apparent definition of the screen image will look much higher than that of the projection system with the same nominal resolution. A series of most advanced features were disclosed step by step.

Fig. 2.2 Polarizing LED 3D movie system was passing technical approval.

The future promises that 3D LED display systems can be installed in modern movie theater chains, or non-chain cinemas such as those in schools or universities, big shopping centers, big meeting and convention rooms and many other public venues seeking latest technology, high brightness and good contrast video exhibition.

MAIN TECHNICAL DESCRIPTION – PATENTED TECHNOLOGIES AND SPECIAL TECHNOLOGIES

In the complete system, many patented technologies and special technologies have been applied [1].

1. SYSTEM CONFIGURATION

For a standard cinema a server should be used to play a film although for some lower ranking cinemas a normal PC could be used to play as well. In a movie city or a movie theater, it is possible that one mainframe computer controls all movie halls.

Hereinafter, the video system is described. It should be noted that for audio, the current audio systems used for projection system can still be utilized. So a venue can use any audio systems.

Fig. 3.1 shows the picture information chain. We hereinafter take L as left (data or picture) and R as right (data or picture), SC as System Control at sender, SN as screen, and PG as polarizing glasses. Normal category 5 or 6 cables are used for data transmission. .

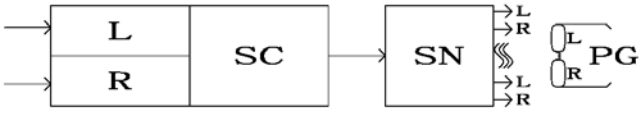

Fig. 3.1 Picture information transmitting chain [1].

2. POLARIZING SYSTEMS

For the polarizing systems, both RealD and Master circular polarizing film, as well as a linear polarizing system were used for the samples of video displays. Any system can be used very well for the LED video displays. However, polarizing glasses should be used accordingly. As for the linear polarizing system, one's head cannot tilt too much, and also for the compatible reason, circular polarizing systems, glasses and film to the video screen are used for the final result.

3. POLARIZING FILM TESTING

The specification from polarizing film factory is as shown in Table 3.1.

Item		Unit	Specs
Single Transmittance		%	42±2
Polarizing Efficiency		%	≥99.5
Retardation Value		nm	138±10
Hue	a*	NBS	-2.0±1.5
	b*	NBS	3.0±1.5
UV Cut at 380nm		%	< 1

Table 3.1 Optical Properties of Polarizing Film [1]

For the brightness of a LED screen, it is not difficult to make it very high. However, for the sample screens, it has been up to 10-20 times higher than a normal silver screen in a cinema projector system (see description in later section). For a specially designed outdoor system, the brightness can be up to thousands nits.

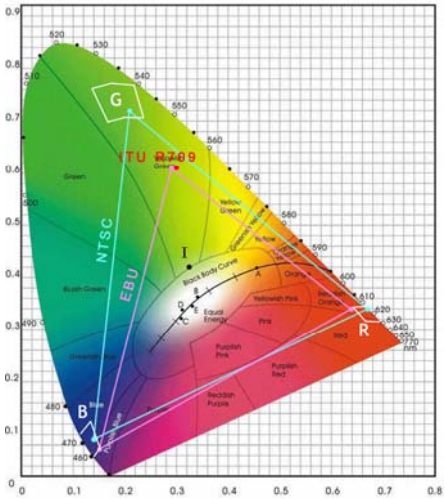

Fig. 3.2 Chromaticity of 3-in-1 LED chips

It has been a long term study and research of how to increase the practical signification in a limited pixel number. Such a study and research started from the year 1976. Then for individual RGB lighting devices both quadruplet and triplet pattern had been applied to the video screens and that had been used for the 11th Asian Games.

For the present 3-in-1 LED pixels, the parity matrix had been considered better than either line-by-line matrix or column-by-column matrix. But it is still not the best way. Nobody can say

that they use half pixels to do the work that should be done by much more pixels. It will be always a problem if one expects that such a solution would be accepted by the movie and cinema industries and their experts.

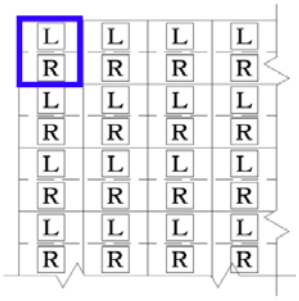

Fig. 3.3 There are two individual pixels in one physical pixel scope [1].

The research and development program over the past years has made many achievements, and at last, a new technology named "Double Channel High Definition (DCHD)" system has been finally determined to provide the answers. DCHD provides new LED 3D movie systems. DCHD is a complete system – not simply a circuit. Essentially, for a chip pixel matrix, two individual pixels are put into one physical pixel area, as shown in Fig. 3.3 [1].

In traditional LED video displays, the data chain could be shown as in Fig. 3.4. However, in DCHD LED 3D display systems shown in Fig. 3.5, dual individual transmissions have been applied to the lighting boards. With one more category 5 or 6 cable being used, such an arrangement ensures DCHD data for both left and right pictures quality from beginning to the end without any loss. This is the important necessity for movie quality that can be transmitting picture data with normal 1.5G systems for 1080i or 3G systems for 1080p data in a 2k system. If just one cable or one fiber-optical is hoped, transmission adaptors should be added at both sides and certainly for both adaptors and transmission cable must suit for double data rate. For 4k and 8k systems, relevant extra equipment should be added.

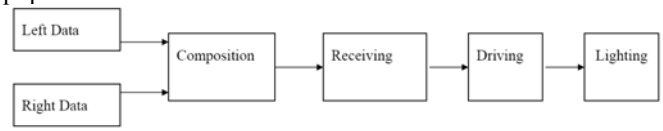

Fig. 3.4 Data chain in a traditional LED 3D display.

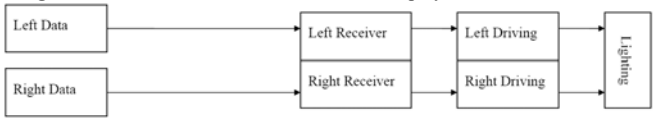

Fig. 3.5 Data chain in DCHD LED 3D systems [1][11][12].

4. Main Differences between HDTV Standard and Cinema Standard

Table 3.2, as an example of 2k system, shows that main differences between TV standard and cinema standard. Of the two main differences between HDTV and cinema standards, it is clear that from ITU recommendations, the horizontal resolution of HDTV is 1920 pixels [6][8]. But for cinema system it is 2048 pixels [2][3][13]. So the video processor should be different. However, this is not difficult. For the Quantizing Depth, both SDTV [7] and HDTV [6] are of 10 bits, and the UHDTV [4][10] could be either 10 bits or 12 bits. For cinema system it is 12 bits [2][3][13]. This concerns not only the video processor but also the driving chips. The latter is much more difficult.

	Resolution	Quantizing Depth
Cinema standard	2048 x 1080	12bits
TV standard	1920 x 1080	10bits
Mainly concerned	Video processor	Video processor and driving IC chips
Compression standards	MPEG	JPEG 2000

Table 3.2 Main Difference between HDTV Standard and Cinema Standard

Anyhow, it should be able to receive 12-bit movie data of both pictures for left eye and right eye without any loss.

Another thing is to fix refreshing frequency as 300 Hz and its times (such as 600 Hz or 900 Hz) and that is also very good, as 300 is 6 times of 50Hz and 5 times of 60 Hz and that can be changed automatically when input varies.

MAIN SPECS OF A TYPICAL 2K CINEMA SYSTEM

Table 4.1 shows the main specs of a typical 2k LED 3D cinema system.

On Table 4.1, both 10 mm and 6 mm systems are of the same resolution and they can cover most cinemas. However, it should be indicated that for the same resolution for both LED 3D system and projector system, the LED system will seem much clearer than a projector system.

No	Name		Value
1	Resolution		2,048 X 1,080 = 2,211,840
2	Pixel Pitch	10mm	20.48 m X 10.8 m = 221.184 m^2
		8mm	16.384 m X 8.704 m = 142.606 m^2
		6mm	12.288 m X 6.48 m = 79.62624 m^2
3	Brightness	10mm	640 cd/m^2
		8mm	600-700 cd/m^2
		6mm	600-800 cd/m^2
4	Viewing Angle		110-120 degree

Table 4.1 Main specs of a typical 2k cinema system

Besides 2k system, both 4k and 8k systems have been also designed.

For picture clarity, resolution will never ever be the only factor. There are many examples can verify that from experience. Such as in China, some person may complain that the "HD movie picture" in a cinema is not clear. When a film expert made an inspection, it was found that the projector can give only very low luminosity. For the existing digital projector systems there are many factors that might cause an unclear picture including but not limited "low brightness, low contrast, defocusing and misconvergence".

Just for these four factors it has been shown from testing that a 2k projector system its practical significant is just like a 1k LED system and a 4k projector system is no better than the significant of a 2k LED system. For details see the following section. So the so said 2k or 4k or so should be real resolution for LED systems and just nominal resolution for projector systems.

MAIN TECHNICAL COMPARISON - A REVOLUTION IN THE CINEMA EXPERIENCE

There are many advantages that in a cinema 3D LED Display over than a digital projector system. Here the main ones are described.

1. RAYS AND LIGHT

A Digital projector shines light onto a screen with beams of light and that affects the audience at the rear of the theater a lot. Unlike a digital projector, an LED 3D display has no beams or rays of light to distract viewers.

2. BRIGHTNESS

Digital projectors are not as bright as 3D LED displays. When using a digital projector it is helpful to close shade windows, close doors and dim lights. Because a 3D LED display is much brighter, it is not necessary to control indoor lighting in order to attain a superior image.

A 3D LED display can be effective even in many outdoor settings conditionally. From the technical approval of the LED system, and from research, the screen brightness is about 14-16 times, or even higher, of a digital projector system. And furthermore see the below "*Not Comfortable Physiological Stimulating*".

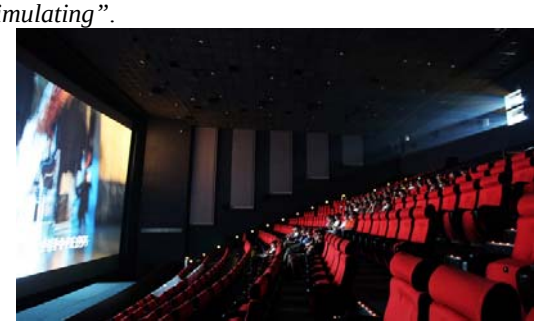

Fig. 5.1 Strong rays from a projector affects back audience

3. CONTRAST

A digital projector has much a lower contrast ratio than a 3D LED display. There are several reasons for this including variable projection screens, projector technology limitations and lighting conditions. Simply speaking, a projector system is of low brightness with white background. But an LED system is of high brightness with dark background. By practical testing, the contrast is will be around dozens times of a digital projector at a certain condition.

4. SWITCH OF DATA SOURCE

Input Source switching is superior and more advanced in 3D LED displays versus digital projectors. And that is very easy to switch to any data source.

5. COMPATIBILITY OF DATA FORMAT

The data format to a projector is limited. However, the data format to an LED screen is not limited. It accepts any electronic format, if and only if it can be played on a computer or a server.

a) A projector system b) An LED system

Fig. 5.2 Practical viewing feeling for a projector system and an LED system

6. DEFOCUSING

Defocusing is a very obvious weakness of digital projectors. Even at the finest adjustment of focus, the focus is always imperfect. The focus imperfections of digital projectors increase with screen size and projection distance. In a 3D LED system there is absolutely no such a problem.

7. MISCONVERGENCE

Digital projectors have a problem with consistent convergence of RGB. Imperfect convergence is demonstrated in Fig 5.3. In a 3D LED system there is absolutely no such a problem.

Fig. 5.3 Misconvergence effect

8. REFLECTION AND GLARE

A digital projector shines light onto a projection screen that can reflect light back into the eyes of the viewer. This reflection can be very distracting at different angles. The lens of projector will produce multiple reflections and that will bring glare. These do not happen with a 3D LED display.

9. REFRESHMENT RATE

Refreshment of a projector system should be 48, 50 Hz or 60 Hz and it is not adjustable. So sometimes it will flicker. In an LED system the refreshment can be preset as 300 Hz or even higher such as 900 Hz, and that can be set at any time

conditionally if it is necessary. There is no flicker in an LED system.

10. LIFE

It is said that life of a good quality lamp of a digital projector can be at most 20,000 hours and the lamp is very expensive. Sometimes of a normal projector system the lamp could have to replace in just one month, at low rank cinemas. Life of an LED system can be up to 100,000 hours.

11. 2D/3D COMPATIBILITY

An LED system can play either 2D or 3D movies without any change for the systems.

12. 3D TV BROADCASTING

The LED 3D cinema can play without any loss. It is easy to switch to a local zone to play 3D TV to any audience. But a projector could not.

13. UNCOMFORTABLE PHYSIOLOGICAL STIMULATING

A person going to a movie theater experiences a "dark adaptation" when entering the theater and then a "bright adaptation" upon leaving. Medical research suggests that the latter of these adaptations may cause visual fatigue and possible long term damage. These adaptations can be eliminated by using 3D LED displays. This is very easy to understand. But on the other hand, for a digital system the screen brightness could be only 48 cd/m^2 [2][3][13], but by writer's experience, the brightness of that could be much lower. At least in China, the practical brightness in many, many cinemas is around 20 cd/m^2 and even lower. For many dark scenes of a movie say, as an example many sceneries of movie, must be very low say, lower than 3 cd/m^2. When the peak brightness of the silver screen is lower than 20 cd/m^2, the low brightness of dark sceneries could be lower than 1 cd/m^2 and that must be even lower after polarizing glasses to the eyes. As by the principle, when the brightness is as low as between 0.01 cd/m^2 to 3 cd/m^2, the Pyramidal cells and Pillar cells of human's eyes will exchange very actively and that must be harmful for human's eyes.

Fig. 5.4 a) Original Picture [13]

14. DECOLORATION

An LED system is from digital to digital and it is a full digital procedure. The chromaticity of an LED won't vary during its life time. But during a projection system there is optical transmission procedure and color filters inside. Besides, the three primaries of color filters could bring different color attenuation under high temperature after a long time heating by the Xenon Lamp.

Fig. 5.4 b) Color attenuated picture in a projector system

For all of the above, a digital projection system has critical weaknesses compared to 3D LED displays. Brightness and contrast are much higher in 3D LED displays. The superior clarity of a 3D LED display is demonstrated in Fig. 5.2. The quality of 3D LED technology has surpassed digital projection. By the testing results, people's practical significant feeling of a 2k projector movie will be no better than the same movie to be played with a 1k LED system.

15. CINEMA PROJECTION ROOM STRUCTURE

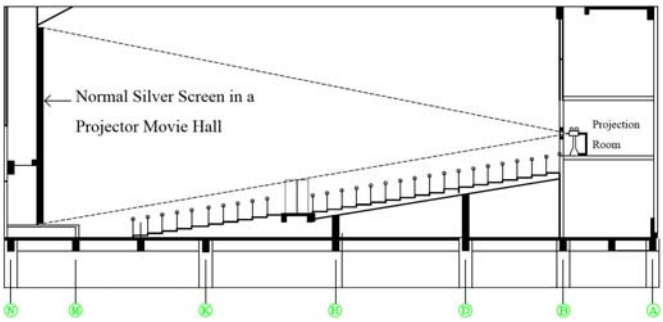

Fig. 5.5 a) There is a special and individual projection room for each movie hall

In a movie theater or a movie city, there could be many movie halls. For example, there could be up to 50 movie halls in one Movie City. For every hall there should be at least one projection room and that must be special and individual. For an LED system, the status should be quite different. There is no need special and individual projection room for each movie hall.

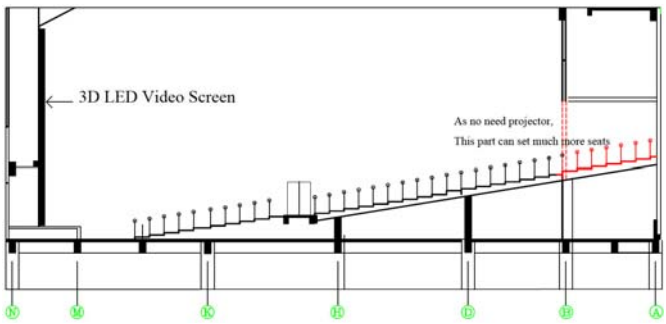

Fig. 5.5 b) Much more seats can be set and playing equipments for all movie halls can be in one room to make centralizing control.

So the rear part for the projection can be moved to set up much more seats. And for all the movie halls in one movie city all the projector the display equipments can be gathered into one room to make centralizing control. To supervise the movie, it is very easy to arrange a normal video camera to do that. Such a way will be suitable for modern management. And that is more useful in a society, such as in America, of that computer technology is very advanced and the labor cost is expensive. In a movie city or a movie theater, it is possible that one computer controls all servers in all movie halls.

PARTICULAR COMPARISON BETWEEN LED 3D SYSTEM AND A TYPICAL PROJECTOR SYSTEM

The following descriptions can make things clearly.

The consumption of a LED system is about 3 times as high as a comparable projector system. But its brightness is about 15 times greater. This is because as known to all, the Xenon Lamp is a very, very low efficiency lighting device. (See Fig. 6.1) - a lot of the Xenon Lamp energy is outside the visible wavelength. Therefore, much of the power that is used for Xenon Lamp display just ends up as heat – not light. On the other hand, an LED is a highly efficient device. Its whole energy is within the visible wavelength. And add with factors, the efficiency of an LED system is about 4-5 times as high as a projector system.

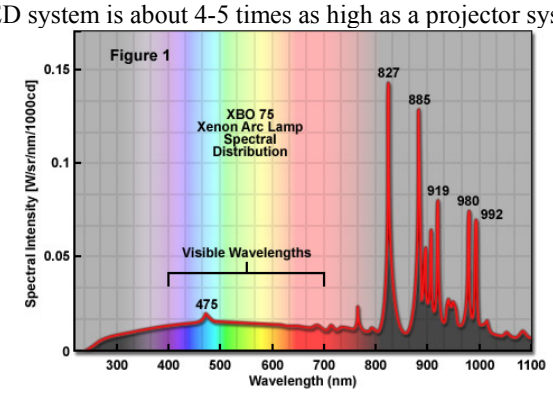

Fig. 6.1 Spectrum of a modern xenon lamp. A big part is outside of the visible wavelength and this is one of the main disadvantages on Xenon Lamp technology.

Certainly by the policy of Energy Star Program, any movie player should be analyzed with its energy efficiency. In lighting systems, just a couple percentage points higher of energy efficiency should be very visible. How about 4-5 times high? Certainly it should be of selective preference. And how about the real consumption that is about 3 times high? The low consumption of a projector system is to take the harm to human's eyes as cost, and such a harm has been removed in an LED system. And by calculation, the cost of consumption of a 220 sq. meter LED screen for every two hours is about one ticket only. Certainly that is very valuable, as it concerns human's health.

Here we have to declare that when we make the brightness of an LED system as the same as a projector system, its consumption will be much lower than a projector system. This means that its efficiency is still high. However, at this some obvious advantage of an LED system such as no "dark and bright adaptations" won't exist. But the advantages of no defocusing, no misconvergence and the very good advantage of almost no "3D vertigo syndrome" (see below section) still keep remained.

No	Item	Projector	LED
1	Typical Size	20.48 X 10.8 = 221.184 m^2	
2	Lighting principle	Screen reflection	Self-lighting
3	Lighting device	Power Xenon Lamp 15kW X 2	LED
4	Power for 3D	30kW	90kW
5	Consumption for 2 hours	60kWh	180kWh
6	Cost for 2 hours power @CNY6.3 = USD 1 The extra cost for LED system is one ticket only	CNY 60 or USD 9.52	CNY 180 or USD 28.57
7	Relative consumption(1)	1	3
8	Relative brightness	1	15
9	Relative efficiency	1	5
10	Relative heating(2)	1	1
11	Heater	Projector	LED screen
12	Life of lighting device	2,000-10,000 hours	100,000 hours
13	Subjective significant feeling	1	2(3)
14	Color revivification	Bad(4)	Good
15	Equipment cost @ CNY 6.15 = USD 1	USD 2.38 million	USD 1.238 million
16	Sequential cost	Cost of Xenon Lamp is high	Normal worker expense
17	Seats(5)	There must be a individual projection room	LED system won't need a projecting room. But all movie equipments in one Movie City can be centralized controlled in one room. So about 20% more seats can be added.

Table 6.1 Comparison between LED 3D system and a typical projector system

Under the same resolution say, 2k X 1k, human's eyes will feel that the definition of an LED system is much higher than a projector system. Because there is no defocus and misconvergence, and its brightness and contrast are also very high. The so said 2k or 4k or so should be practical resolution for LED systems and just nominal resolution for projector systems.

An LED system is from digital to digital and it is a fully digital procedure. The chromaticity of an LED won't vary during its life time. But within the projection procedure there is optical transmission that occurs and the three primary color filters could result in different color attenuation under high

temperature over an extended operating period – caused by the heat generated by the Xenon Lamp.

As there is no projection room, the number of seats in a cinema with LED system can be about 10-20% more than a projector system. Be sure there is no projecting rays above the back audience.

So a very serious question should be made: When the movie technicians are making the resolution much higher than 2k, what is the best one in resolution?

About the consumption, there could be the following three choices:
1. To keep the 3 times of consumption of an LED system to a projector system. The brightness should be about 15 times as high as a projector system. There is no "dark and bright adaptations". The cost of the higher consumption of an LED system is about one ticket only.
2. To make the consumption of an LED system the same as a projector system and the brightness will be about 4-5 times of a projector system. In such a way the "dark and bright adaptations" could be much better than a projector system but it still exists.
3. To make the brightness of an LED system as the same as a projector system. The consumption will become much lower than a projector system. In such a way the "dark and bright adaptations" should be the same or similar of a projector system.
In any of the above three, it meets the request of the Energy Star Program. And some other advantages will still exist. The writer is thinking that as there are too many advantages in a standard LED system, the above No. 1 should be preferred. When we paid a ticket to buy human's health, it must be very, very worth.

IMPORTANCE FOR HUMAN'S HEALTH

As described above, a person going to a movie theater experiences a "dark adaptation" when entering the theater and then a "bright adaptation" upon leaving. This could be harmful for human's eyes. In an LED system, there are no such adaptation procedures. Furthermore, there is no defocusing and misconvergence and there is inherent higher brightness and higher contrast.

From our research these are not all advantages of an LED system. These benefits are just good for the eyes mainly. As there have been many papers including titles such as "3D Vertigo Syndrome" and "Observational Study on Visually Induced Motion Sickness" published for research for visual health, and reports on the effects on the human brain. As an extreme example by a report, a 42-year-old man in Taiwan was claimed to have died from watching the 3-D movie "Avatar". The man, last name Kuo, is said to have had a history of high blood pressure. During the screening, in the Taiwanese city of Hsinch (*should be Hsinchu--writer*), Kuo reportedly began to feel unwell and by the time he reached the hospital he was unconscious. A scan showed that his brain was hemorrhaging. Kuo died 11 days later.

Many papers and reports indicated that that the so said "3D vertigo syndrome" does exist. As an example, it is described in one paper as:

"A prospective carryover observational study was designed to assess the effect of exposure (3D vs. 2D movie views) on self reported symptoms of visually induced motion sickness. The standardized Simulator Sickness Questionnaire (SSQ) was self administered on a convenience sample of 497 healthy adult volunteers before and after the vision of 2D and 3D movies. Viewers reporting some sickness (SSQ total score>15) were 54.8% of the total sample after the 3D movie compared to 14.1% of total sample after the 2D movie. Symptom intensity was 8.8 times higher than baseline after exposure to 3D movie (compared to the increase of 2 times the baseline after the 2D movie)." In the paper the Conclusion is "Seeing 3D movies can increase rating of symptoms of nausea, oculomotor and disorientation, especially in women with susceptible visual-vestibular system. Confirmatory studies which include examination of clinical signs on viewers are needed to pursue a conclusive evidence on the 3D vision effects on spectators." [16]

	After Vision of 2D Movie	After Vision of 3D Movie
Symptom report	14.1%	54.8%
Symptom intensity report		8.8 times (to 2D)
The standardized Simulator Sickness Questionnaire (SSQ) was self administered on a convenience sample of 497 healthy adult volunteers		

Table 7.1 Research result by Prof. Angelo G. Solimini, Department of Public Health and Infectious Diseases, Sapienza University of Rome, Italy

Why does such "3D vertigo syndrome" exist? Some persons have given a lot of various explanations. Here we are trying to give quite different assumption. As per the writer's research, at the very primary stage of testing of a polarizing LED stereoscopic movie system, such a "3D vertigo syndrome" should be rather low. By further research and development, when the world's first commercial "Double-Channel HD" polarizing LED 3D system installed, we did invite many lots of persons come to watch movies, especially the famous movies that could bring "3D vertigo syndrome". And so, even some persons were watching movies in a continuous 5-6 hours, and even 40 persons with age between 60 and 66 were invited to come to see a stereoscopic movie for 2.5 hours. None of them reported any vertigo or so, just like seeing a normal 2D movie. We do think that is a very important thing for the quite new system. Then we started to be supposing that the reason of "3D vertigo syndrome" by a normal projector system should be from "Optical Jitter". In many cases some micro "Jitter" can bring human's vertigo. For example, in "Wenchuan Earthquake" in China in 2008, many people, who live far from

the earthquake center, didn't feel the earthquake but felt vertigo or headache. With a 3D projector system there are two projectors and they could bring different, very fast but very micro shakes. We can call that as "optical jitter". For a 2D projector system the jitter to the two eyes are the same amplitude and the same direction. For a 3D system, as the two jitters can be quite different direction and amplitude. So human's optic nerve and central nervous system cannot make them balanced so the both jitters will make different reports to the brain. So "3D vertigo syndrome" occurs. We submit here as a quite new theory that we think at least that can explain most "3D vertigo syndrome" For example, why there is no 3D vertigo syndrome in a holographic system? As if there is any jitter inside, that should be of the same (or similar) direction and amplitude to two eyes. So human's optic nerve and central nervous system can accept it. When 2D status, our eyes will make only report to our brains so our brain will feel that is correct. When 3D status, our brains will receive two different reports so our brains cannot know which is correct. So the "3D vertigo syndrome" must occur.

So the so said "3D vertigo syndrome" does not exist in an LED system at all? The answer is not all. At per our further research, we did find some 3D video programs can bring 3D vertigo syndrome. And by tests, we do think that can strength and enhance our new theory. As the so said optical jitters can exist in both video camera side and projector side, and as we can analyze, the effects of jitter at camera side should be much smaller than that at projector side. So the optical jitter brought by cameras won't show. And as there is no optical jitter in an LED system, this is the main reason why one can difficultly feel 3D vertigo or headache from an LED system. Some 3D video programs can bring 3D vertigo syndrome in an LED system as that could use poor quality 3D cameras. So by the research, the conclusion of whole thing should be like this: At both camera side and projector side the jitters do exist. The jitter at camera side could be much smaller than the projector side. As the optical jitters at both projectors for stereoscopic movie are of different amplitudes and directions, two eyes are sending to the brain different reports. So the "3D Vertigo Syndrome" occurs. However, as in an LED system there is no optical jitter on the screen, one could feel there is no, or very low, "3D Vertigo Syndrome". In this case the jitters that brought by the double cameras could become the main ones. But at most cases, the jitters that brought by the double cameras could be of similar amplitude and the same direction. Then we still could not feel "3D Vertigo Syndrome". However, for some movie when the cameramen used poor quality cameras, the "3D Vertigo Syndrome" could occur as well. By the tests, the different gen-lock between double cameras could affect such jitters either. When we make the result very clear, we could be able to remove the optical jitter and then remove the "3D Vertigo Syndrome" greatly. Here something should be corrected:

1. How about visual fatigue will also occur when we see a 2D movie a long time, much less 3D? So we should make it clear that what we are talking about is "3D Vertigo Syndrome" instead of normal visual fatigue. As a reference of what had been described by Prof. Angelo G. Solimini, Department of Public Health and Infectious Diseases, Sapienza University of Rome, Rome, Italy, when the sickness report ratio is lower than 14.1%, we can say that is not "3D Vertigo Syndrome" [16].

2. One could say when too exciting 3D pictures there are lots of things such as a waving sword or many stones always move to your eyes, some persons will feel vertigo. We say: yes, one could feel vertigo. However, that won't be 3D vertigo, as in our real daily life, when a waving sword or many stones should were always moving towards to your face, some could also feel vertigo but that is not "3D vertigo". That is different exciting.

Fig. 7.1 First commercial polarizing LED 3D movie system

Fig. 7.2 60-66 years-old people were watching a 3D movie.

Besides all the advantages described above, we have to mention that such technology can have the stereoscopic effects of movies improved greatly. Certainly, the 3D effects should be the business of cameramen. However, just due to mainly "3D vertigo syndrome", our cameramen sometimes will be afraid of that the frequent and too exciting pictures such as something is always moving towards your face, could bring no good side effect of vertigo. So when our cameramen make movie picture they will make painstakingly some hesitation for hold back to avoid bad thing occur. This will certainly affect the result of the stereoscopic effects of the movie. Some people especially young people could always complain of the stereoscopic movie is not "3D" enough. Now all the respects that could bring "3D vertigo syndrome" had been described clearly. By tests, we played couple hours of very exciting movie parts continuously, all the audience including some persons with age didn't report any obvious vertigo or so. So we can expect when such a quite new theory has been thoroughly discussed very clearly, the movie picture could become much more "3D" still without "3D vertigo syndrome". That will be mainly select the LED Stereoscopic Movie Player as the main players in the movie theaters, and use cameras

with very good quality that includes but not limited very good gen-lock between double cameras system.

The result of final research is as follows:

1. To use the shutter mode LED display, moderate "3D vertigo syndrome" that is visual fatigue appears. That is as in a shutter mode system, anytime there must be two different reports from one's two eyes to one's brain, even if the time difference could be small.

2. To remove the Gen-lock between two cameras, when the picture was played, moderate "3D vertigo syndrome" appears. The reason has been described above.

3. To resume the Gen-lock between cameras, but switch the both left and right pictures in a different time say, one is lagged for half second (test purpose). One can feel very bad vertigo. The vertigo could be much heavier than that one did see a couple hours of 3D movies. See Fig. 7.3, when the screen plays with left picture is of Movie A and right picture is of Movie B. When one didn't wear any 3D glasses, one will feel look like one is facing a window glass and of that one can feel like through the glass an inside thing and a reflected thing together. As the two eyes made the same report to ones brain, there is no any vertigo just the picture is not clear.

Fig. 7.3 Left picture is of Movie A and right picture is of Movie B.

However, when one wears on a pair of polarizing glasses, one will feel very strong vertigo that is like one has watched a very long time of 3D movies. This not only makes the verification of our research, but also from this, we can see that the LED 3D movie player can become a controllable tool to research the "3D vertigo syndrome".

The final conclusion is that if and only if the optic nerves of two eyes make different reports to ones brain in any reason, that could bring ones brain cause don't judge information, the "3D vertigo syndrome" must occur. In a DLP system the micro mirrors did fast mechanical movement, and in LCD system the liquid crystal move and remove fast when it scans. Just in an LED system there is no any movement when it lights.

Here we think we have to mention again that we have to discuss the real resolution again. That is as for a projector system, the so said resolution is its nominal number only. But the resolution of an LED system is its real physical resolution. What we have to discuss is the real resolution that we are really in need. This is as when we seek for higher resolution, the relevant sources must follow up either. Some waste could occur.
And as we know, the function of a pair of polarizing glasses is as a separator for left and right pictures. From the serial research and tests, the separation is also important. In the LED system, the separation has been made up no less than 99.8%. That should be also better than a projector system.

CONCLUSION

Compared with the digital projector system in a cinema, there are too many advantages for the LED 3D cinema system:
1. There is no defocus and misconvergence. Both brightness and contrast are much higher. The significant of 1k LED system looks no poorer than a 2k projection system.
2. There are no "dark adaptation" and "bright adaptation" That is very good for human's health.
3. Efficiency is much higher than a projector system. It meets the program of "Energy Star".
4. It is 100% compatible with 3D broadcasting TV.
5. Very importantly, the problem of "3D vertigo syndrome" can be omitted. This is very important thing for human's health.
From the above, we can see that the LED 3D movie player can become a controllable tool to research the "3D vertigo syndrome". That is as the so said "3D vertigo syndrome" cannot be removed from a projector system. But in an LED movie player there should be almost no "3D vertigo syndrome". But we can let it produce some "3D vertigo syndrome" from it. That is useful to make further research for the "3D vertigo syndrome".
So we do think it must be developed very strongly. Maybe its advantage for human's health should be the most important contribution of LED stereoscopic movie system.

How about the possibility of replacing of LED system to present projector system? The writer is thinking that is "only a matter of time" despite that how that could be delayed.

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BIOGRAPHY

Chao Li was born in Shandong, China, March 1951. He is the President of Central China Display Laboratories, Ltd. (CCDL). Graduated from Wuhan University of Science and Technology in 1976; Distinguished Professor of Wuhan University of Science and Technology. In 1986, he was awarded as "China National Expert with Outstanding Achievements" by National Committee of Science and Technology of China. In 1988, led by Chao Li, CCDL set up the first color video display system in China, for the First National Farmer Games. In 1989, set up the display system for the 11th Asian Games, Beijing. In 1998, won the tenders of both LED display systems for Sydney Olympics. He is a member of: SMPTE – Professional; IEEE – Professional; 3D Professional Committee of China Society of Image & Graphics (Senior Advisor); Technical Committee of China Radio & TV Association; Technical Group of China Optics & Optoelectronics Manufacturers Association LED Division. Developed the world's first shutter mode 3D LED display system in 1997.